Supplementary Information for

Earth's inner core composition inferred from the equations of state of Fe-Si-C-H alloys

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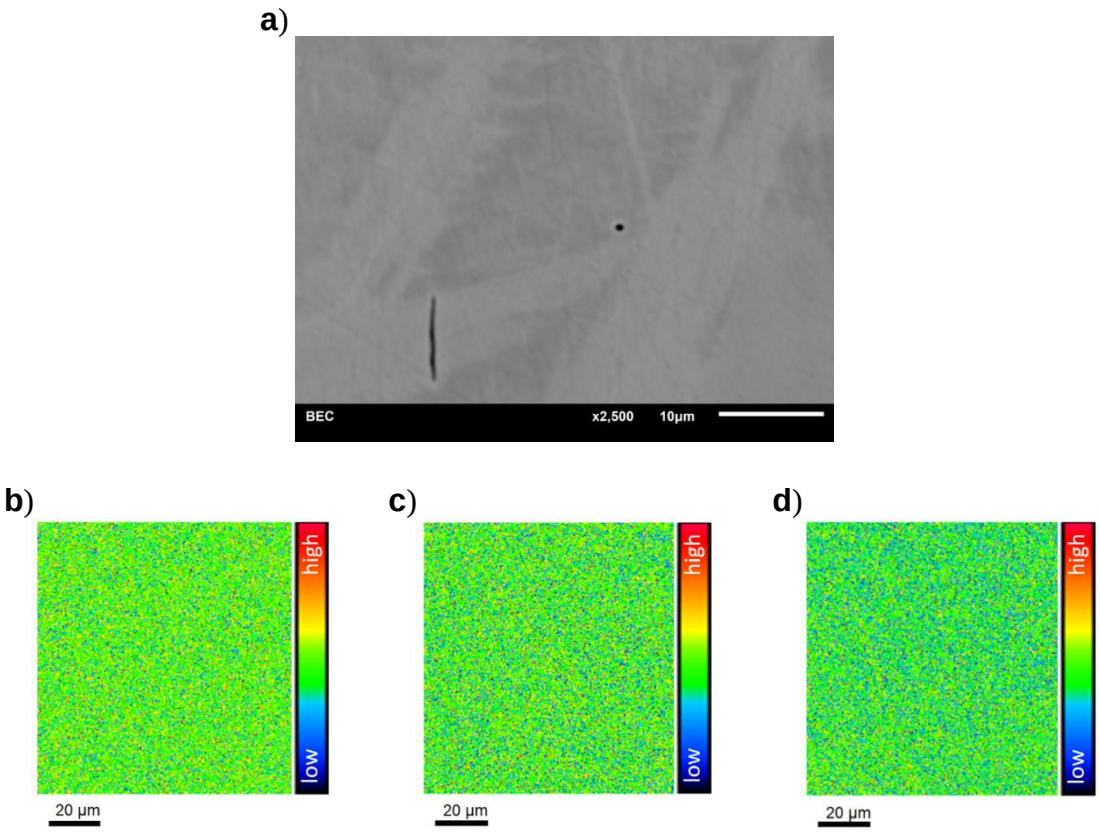
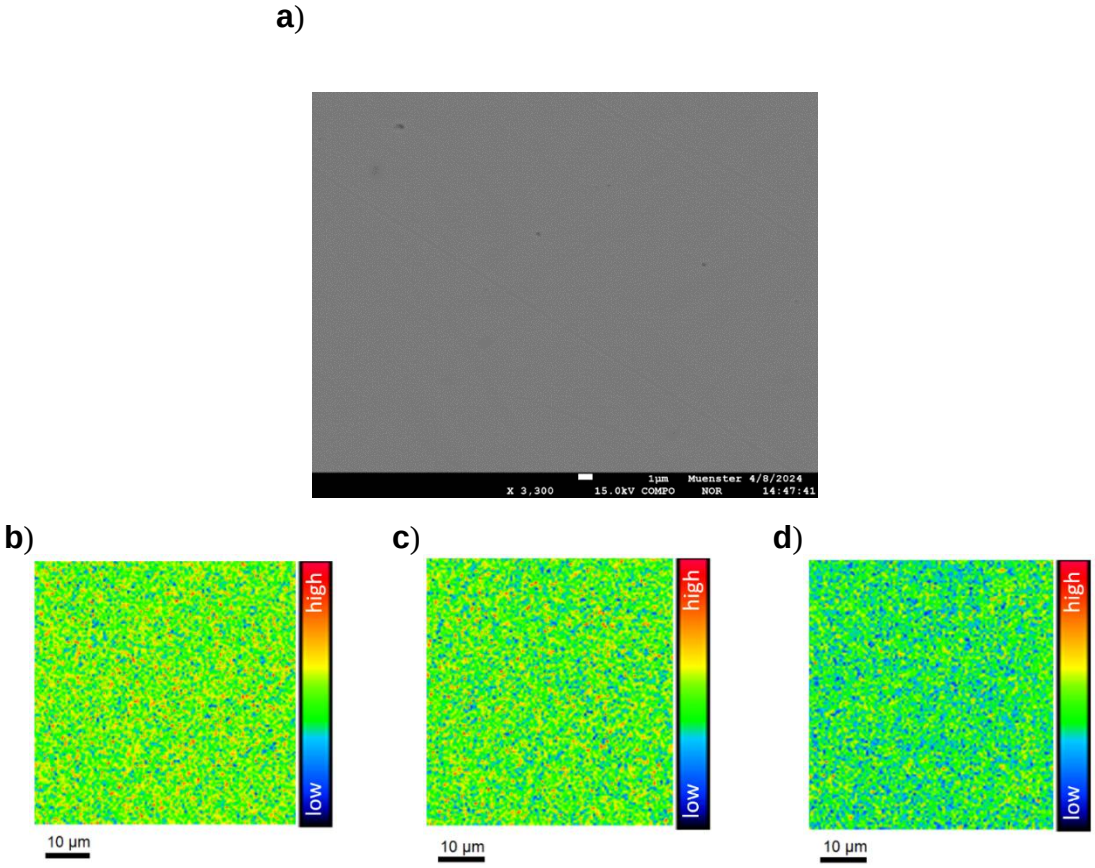
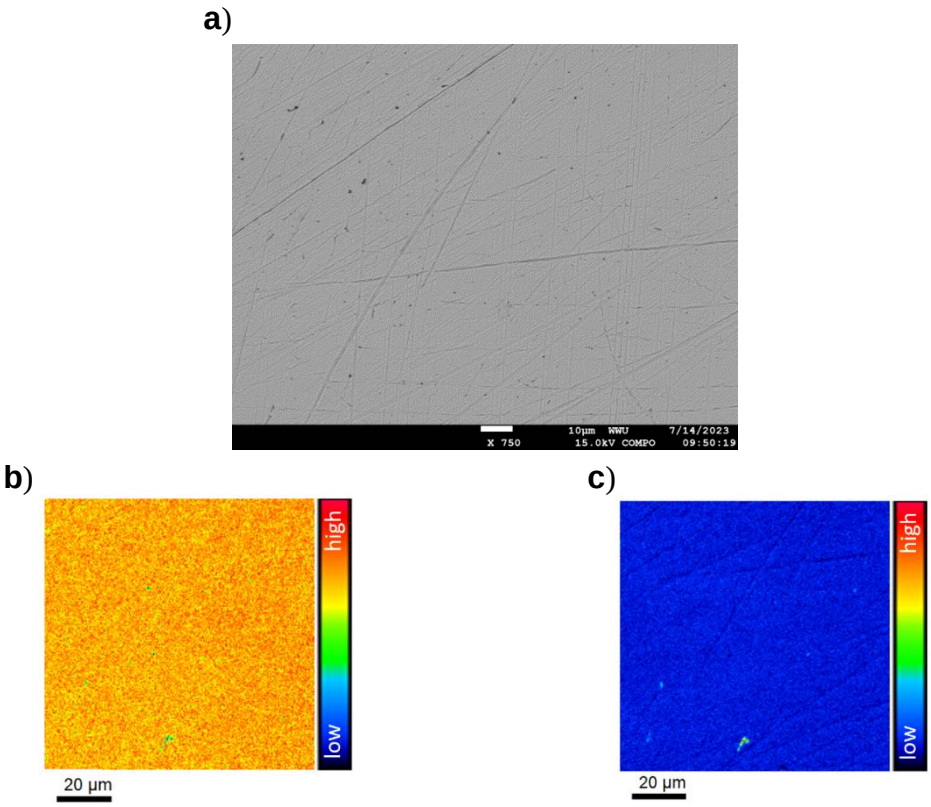


Supplementary Fig. 1 | Backscattered electron image of the (Fe-1.9Si)$C_{0.09}$ sample after the synthesis (a) and qualitative elemental X-ray distribution maps for Fe (b), Si (c) and C (d) in (Fe-1.9Si)$C_{0.09}$. Scales on the right in **b**, **c**, and **d** correspond to relative element concentration: low (blue) or high (red). The center of all four images is the same.

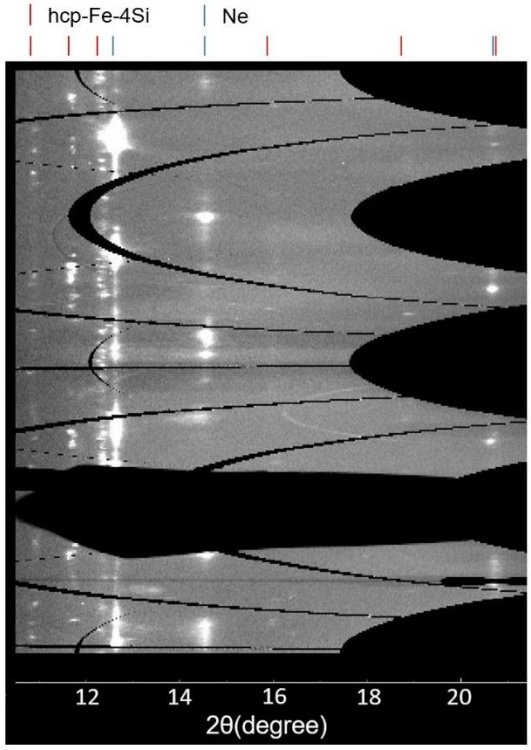


Supplementary Fig. 2 | Backscattered electron image of the (Fe-1.5Si)$C_{0.01}$ sample after the synthesis (a) and qualitative elemental X-ray distribution maps for Fe (b), Si (c) and C (d) in (Fe-1.5Si)$C_{0.01}$. Scales on the right in **b**, **c**, and **d** correspond to relative element concentration: low (blue) or high (red). The center of all four images is the same.



Supplementary Fig. 3 | Backscattered electron image of the Fe-4Si sample after the synthesis (a) and qualitative elemental X-ray distribution maps for Fe (b) and Si (c) in Fe-4Si. Scales on the right in **b** and **c** correspond to relative element concentration: low (blue) or high (red). The center of all three images is the same.

a)



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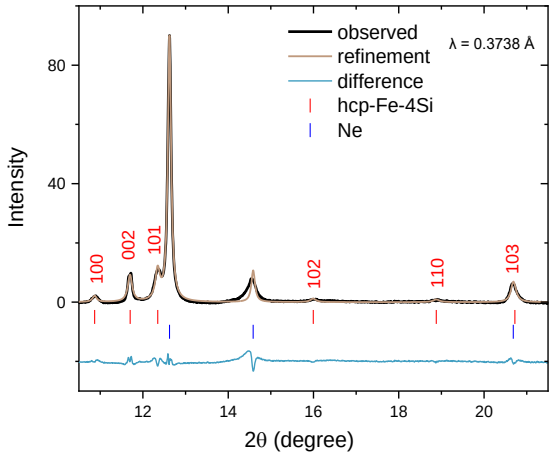

Supplementary Fig. 4 | Example of an unrolled two-dimensional XRD pattern of hexagonal Fe-4Si in the Ne pressure medium, taken at 109 GPa (a) and corresponding integrated pattern (b). Numbers in brackets (e.g., 110) indicate the Laue indices of the Bragg reflections of the hcp-Fe-4Si phase.

Supplementary Table 1. Unit cell parameters of the KCl pressure standard and $(Fe\text{-}1.9Si)C_{0.09}$ sample along with the experimental pressure (P) conditions and volumes per formula unit in $(Fe\text{-}1.9Si)C_{0.09}$ (V). The numbers between parentheses represent the error bar.

a, Å (KCl)	P, GPa	a, Å ($(Fe\text{-}1.9Si)C_{0.09}$)	c, Å ($(Fe\text{-}1.9Si)C_{0.09}$)	V, Å^3
3.2573(5)	27.7(2)	2.4456(11)	3.8836(4)	10.02(15)
3.2482(4)	28.78(6)	2.4402(11)	3.8789(5)	9.985(10)
3.2422(11)	29.45(15)	2.4369(11)	3.8738(5)	9.961(9)
3.2356(5)	30.30(6)	2.4356(11)	3.8707(5)	9.943(9)
3.1957(5)	35.90(7)	2.4249(9)	3.8518(7)	9.808(8)
3.1634(11)	41.1(2)	2.4142(9)	3.8343(8)	9.677(8)
3.1387(5)	45.40(12)	2.4054(10)	3.8209(8)	9.573(8)
3.1202(11)	48.9(3)	2.3975(11)	3.8094(8)	9.482(9)
3.1029(7)	52.42(15)	2.3920(11)	3.8009(8)	9.417(9)
3.0985(7)	53.36(16)	2.3903(11)	3.7970(9)	9.394(10)
3.0870(8)	55.84(18)	2.3854(11)	3.7917(9)	9.343(10)
3.0670(8)	60.4(2)	2.3804(11)	3.7820(9)	9.28(9)
3.0554(15)	63.2(4)	2.3752(11)	3.7737(9)	9.218(9)
3.0426(8)	66.5(2)	2.3704(11)	3.7663(9)	9.163(10)
3.0361(8)	68.2(2)	2.3661(11)	3.7615(9)	9.119(9)
3.0255(9)	71.0(3)	2.3643(14)	3.7527(11)	9.08(10)
3.0151(9)	73.9(3)	2.3608(11)	3.7476(10)	9.045(10)
3.0045(9)	77.0(3)	2.3564(11)	3.7401(10)	8.992(10)
2.9920(9)	80.8(3)	2.3523(11)	3.7354(9)	8.95(9)
2.9878(10)	82.1(3)	2.3496(11)	3.7291(10)	8.914(9)
2.9801(10)	84.5(3)	2.3454(11)	3.7212(10)	8.864(9)

2.9717(10)	87.3(3)	2.3439(11)	3.7154(10)	8.839(9)
2.9623(10)	90.5(3)	2.3408(10)	3.7089(9)	8.8(8)
2.9555(9)	92.8(3)	2.3364(10)	3.7024(9)	8.752(8)
2.9463(11)	95.6(4)	2.3336(10)	3.6954(10)	8.725(9)
2.9376(10)	96.1(5)	2.3302(10)	3.6885(10)	8.714(8)
2.9319(10)	99.3(4)	2.3268(10)	3.6827(10)	8.673(8)
2.9291(14)	101.5(4)	2.3261(10)	3.6799(10)	8.634(8)
2.9242(13)	102.6(6)	2.3233(8)	3.6771(9)	8.622(8)
2.9209(15)	104.5(5)	2.3225(9)	3.6752(10)	8.595(7)
2.9099(16)	105.8(6)	2.3159(9)	3.6681(10)	8.585(7)
2.9049(11)	110.3(7)	2.3135(9)	3.6645(9)	8.519(8)
2.9012(13)	112.4(5)	2.3127(7)	3.6624(9)	8.493(7)
2.8964(14)	113.9(6)	2.3101(9)	3.6571(9)	8.482(6)
2.8899(14)	116.0(6)	2.3062(9)	3.6537(10)	8.451(7)
2.8837(14)	118.9(6)	2.3034(9)	3.6502(10)	8.414(7)
2.8806(16)	121.7(6)	2.3032(11)	3.6450(11)	8.386(7)
2.8730(15)	123.1(7)	2.2994(8)	3.6431(9)	8.373(9)
2.8698(16)	126.6(7)	2.2969(9)	3.6400(10)	8.341(7)
3.2573(5)	128.1(8)	2.4456(11)	3.8836(4)	8.316(7)

Supplementary Table 2. Unit cell parameters of the KCl pressure standard and $(Fe\text{-}1.5Si)C_{0.01}$ sample along with the experimental pressure (P) conditions and volumes per formula unit in $(Fe\text{-}1.5Si)C_{0.01}$ (V). The numbers between parentheses represent the error bar.

a, Å (KCl)	P, GPa	a, Å ($(Fe\text{-}1.5Si)C_{0.01}$)	c, Å ($(Fe\text{-}1.5Si)C_{0.01}$)	V, Å^3
3.2223(5)	32.08(7)	2.4295(8)	3.8909(15)	9.945(8)
3.2142(5)	33.20(7)	2.4270(8)	3.8868(14)	9.913(8)
3.2111(5)	33.64(7)	2.4259(8)	3.8852(15)	9.901(8)
3.1920(5)	36.45(8)	2.4202(9)	3.8751(15)	9.828(8)
3.1841(5)	37.67(8)	2.4168(10)	3.8710(17)	9.791(9)
3.1792(5)	38.45(8)	2.4155(9)	3.8683(16)	9.774(9)
3.1737(5)	39.33(10)	2.4088(9)	3.8665(13)	9.714(8)
3.1612(5)	41.41(10)	2.4043(8)	3.8585(13)	9.658(8)
3.1549(5)	42.50(11)	2.4022(8)	3.8545(13)	9.632(8)
3.1462(5)	44.03(11)	2.3995(7)	3.8505(11)	9.600(7)
3.1337(5)	46.33(12)	2.3949(8)	3.8410(11)	9.539(7)
3.1284(5)	47.34(12)	2.3933(8)	3.8373(11)	9.517(7)
3.1239(5)	48.20(12)	2.3908(8)	3.8349(11)	9.492(7)
3.1105(7)	50.86(14)	2.3858(7)	3.8253(11)	9.428(7)
3.1050(7)	52.00(14)	2.3829(7)	3.8210(11)	9.395(7)
3.0929(8)	54.56(17)	2.3777(7)	3.8116(11)	9.331(6)
3.0866(7)	55.92(16)	2.3753(7)	3.8068(10)	9.300(6)
3.0726(7)	59.12(17)	2.3689(7)	3.7959(11)	9.224(6)
3.0677(5)	60.26(14)	2.3662(5)	3.7929(10)	9.196(6)
3.0581(8)	62.57(20)	2.3621(7)	3.7847(11)	9.144(6)
3.0526(8)	63.94(20)	2.3594(7)	3.7807(11)	9.113(6)

3.0451(8)	65.82(20)	2.3560(5)	3.7761(10)	9.076(6)
3.0402(8)	67.08(20)	2.3538(7)	3.7718(11)	9.049(6)
3.0314(9)	69.41(20)	2.3500(7)	3.7662(11)	9.007(6)
3.0267(8)	70.70(20)	2.3479(5)	3.7638(10)	8.984(5)
3.0239(8)	71.46(20)	2.3464(7)	3.7612(11)	8.967(6)
3.0139(8)	74.26(20)	2.3417(7)	3.7528(11)	8.911(6)
3.0112(8)	75.05(20)	2.3406(7)	3.7515(11)	8.899(6)
3.0045(8)	77.00(20)	2.3376(7)	3.7462(11)	8.864(6)
2.9932(7)	80.41(20)	2.3326(7)	3.7374(11)	8.806(6)
2.9840(5)	83.31(20)	2.3275(7)	3.7296(11)	8.749(6)
2.9743(5)	86.45(20)	2.3231(7)	3.7217(14)	8.698(7)
2.9609(4)	90.95(13)	2.3172(4)	3.7121(7)	8.631(3)
2.9580(2)	91.97(10)	2.3152(5)	3.7102(11)	8.611(5)
2.9562(2)	92.61(7)	2.3141(5)	3.7080(9)	8.598(4)

Supplementary Table 3. Unit cell parameters of the Ne pressure standard and Fe-4Si sample along with the experimental pressure (P) conditions and volumes per formula unit in Fe-4Si (V). The numbers between parentheses represent the error bar.

a, Å (Ne)	P, GPa	a, Å (Fe-4Si)	c, Å (Fe-4Si)	V, Å^3
3.31349(18)	26.654(18)	2.4292(5)	3.9107(11)	9.993(6)
3.31362(13)	26.641(14)	2.4296(5)	3.9093(13)	9.993(6)
3.31201(13)	26.810(15)	2.4290(5)	3.9104(11)	9.991(6)
3.2967(3)	28.45(3)	2.4254(5)	3.9038(14)	9.944(6)
3.28115(18)	30.23(2)	2.4206(5)	3.8979(11)	9.890(6)
3.2530(2)	33.72(3)	2.4113(5)	3.8870(11)	9.786(6)
3.25041(18)	34.06(2)	2.4112(5)	3.8850(11)	9.781(6)
3.23969(16)	35.50(2)	2.4079(5)	3.8800(10)	9.741(5)
3.22593(16)	37.43(2)	2.4036(4)	3.8727(7)	9.688(4)
3.21001(18)	39.80(3)	2.3979(4)	3.8626(7)	9.618(4)
3.1944(2)	42.26(3)	2.3902(5)	3.8532(7)	9.532(5)
3.18435(16)	43.93(3)	2.3880(5)	3.8466(5)	9.499(4)
3.17748(14)	45.10(3)	2.3837(4)	3.8415(5)	9.452(4)
3.16803(13)	46.76(3)	2.3798(4)	3.8365(5)	9.409(3)
3.14841(12)	50.41(2)	2.3700(4)	3.8239(2)	9.301(3)
3.14721(19)	50.64(4)	2.3684(5)	3.8212(5)	9.281(4)
3.14644(16)	50.80(3)	2.3686(4)	3.8203(4)	9.281(4)
3.13850(19)	52.36(4)	2.3679(5)	3.8156(8)	9.264(4)
3.13213(13)	53.65(3)	2.3667(4)	3.8124(4)	9.247(3)
3.12635(14)	54.84(3)	2.3623(2)	3.8077(4)	9.201(3)
3.11965(18)	56.27(4)	2.3579(2)	3.8028(4)	9.155(3)
3.10990(13)	58.40(3)	2.3519(2)	3.7970(2)	9.095(2)

3.07292(10)	67.22(3)	2.3410(5)	3.7671(2)	8.940(4)
3.06911(9)	68.20(2)	2.3440(7)	3.7604(2)	8.947(6)
3.06709(9)	68.72(2)(	2.3406(7)	3.7594(4)	8.918(6)
3.06369(10)	69.62(3)	2.3423(10)	3.7573(5)	8.926(8)
3.05957(9)	70.72(2)	2.3388(8)	3.7539(4)	8.892(6)
3.05637(11)	71.58(3)	2.3383(10)	3.7460(5)	8.869(8)
3.04886(11)	73.65(3)	2.3314(5)	3.7425(4)	8.808(5)
3.04499(11)	74.73(3)	2.3297(5)	3.7391(2)	8.788(4)
3.04147(12)	75.74(3)	2.3292(5)	3.7364(2)	8.778(4)
3.03705(13)	77.02(4)	2.3241(4)	3.7362(4)	8.739(4)
3.03460(13)	77.74(4)	2.3239(4)	3.7370(4)	8.740(4)
3.03034(12)	79.00(4)	2.3251(5)	3.7339(4)	8.741(4)
3.02649(12)	80.16(4)	2.3222(4)	3.7309(4)	8.712(3)
3.02068(13)	81.94(4)	2.3199(4)	3.7252(4)	8.681(3)
3.01704(12)	83.08(4)	2.3177(4)	3.7229(5)	8.660(3)
3.01434(12)	83.93(4)	2.3160(4)	3.7224(5)	8.646(3)
3.01096(11)	85.01(4)	2.3148(4)	3.7199(5)	8.631(3)
3.00590(12)	86.65(4)	2.3165(5)	3.7111(5)	8.624(5)
3.00449(12)	87.12(4)	2.3143(7)	3.7106(5)	8.606(5)
3.00231(12)	87.84(4)	2.3158(5)	3.7069(5)	8.608(5)
2.99926(11)	88.85(4)	2.3132(5)	3.7047(4)	8.584(4)
2.99657(9)	89.76(3)	2.3119(5)	3.7017(4)	8.568(4)
2.99333(10)	90.87(3)	2.3100(5)	3.6996(4)	8.549(4)
2.99098(10)	91.68(4)	2.3087(5)	3.6969(4)	8.533(5)
2.98886(10)	92.42(3)	2.3077(5)	3.6948(4)	8.520(4)

2.98539(10)	93.63(4)	2.3072(5)	3.6913(4)	8.509(4)
2.98272(11)	94.58(4)	2.3051(5)	3.6882(4)	8.486(4)
2.97763(12)	96.42(4)	2.3021(5)	3.6824(4)	8.451(4)
2.97504(13)	97.37(5)	2.3001(5)	3.6834(5)	8.438(5)
2.96949(10)	99.42(4)	2.2927(4)	3.6886(4)	8.396(3)
2.96631(9)	100.63(3)	2.2917(5)	3.6863(4)	8.384(4)
2.95594(11)	104.64(4)	2.2827(5)	3.6774(2)	8.298(4)
2.95324(12)	105.71(5)	2.2823(9)	3.6735(7)	8.286(7)
2.94658(12)	108.40(5)	2.2783(5)	3.6686(5)	8.246(4)
2.94456(9)	109.22(4)	2.2790(4)	3.6680(4)	8.250(4)

Supplementary Table 4. Unit cell parameters of the Au pressure standard and (Fe-4Si)$H_{0.1}$ sample along with the experimental pressure (P) conditions and volumes per formula unit in (Fe-4Si)$H_{0.1}$ (V). The numbers between parentheses represent the error bar.

a, Å (Au)	P, GPa	a, Å ((Fe-4Si)$H_{0.1}$)	c, Å ((Fe-4Si)$H_{0.1}$)	V, Å^3
3.9224(13)	27.65(3)	2.4413(11)	3.942(4)	10.173(14)
3.9153(13)	29.41(4)	2.4369(13)	3.920(4)	10.080(15)
3.9076(13)	31.36(4)	2.4342(13)	3.898(4)	10.000(15)
3.8986(13)	33.72(5)	2.4293(13)	3.892(4)	9.945(15)
3.8867(13)	36.96(4)	2.4215(13)	3.894(4)	9.886(15)
3.8806(13)	38.67(5)	2.4148(8)	3.890(2)	9.822(9)
3.8744(13)	40.48(5)	2.4109(8)	3.886(2)	9.780(9)
3.8598(13)	44.89(6)	2.4011(7)	3.883(2)	9.693(8)
3.8564(13)	45.94(6)	2.3991(7)	3.872(2)	9.651(9)
3.8487(13)	48.42(5)	2.3949(7)	3.865(2)	9.599(8)
3.8433(13)	50.18(5)	2.3934(7)	3.852(2)	9.554(8)
3.8390(13)	51.63(6)	2.3925(7)	3.841(2)	9.521(7)
3.8360(13)	52.65(6)	2.3909(5)	3.8308(18)	9.483(6)
3.8317(13)	54.11(4)	2.3888(5)	3.8196(17)	9.438(6)
3.8286(13)	55.20(4)	2.3842(5)	3.8205(18)	9.404(6)
3.8249(13)	56.51(5)	2.3817(8)	3.819(2)	9.381(8)
3.8191(13)	58.59(5)	2.3785(9)	3.816(3)	9.348(10)
3.8170(13)	59.39(5)	2.3778(9)	3.811(3)	9.329(10)
3.8130(13)	60.85(5)	2.3764(11)	3.799(4)	9.290(12)
3.8091(13)	62.31(5)	2.3756(10)	3.797(3)	9.278(11)
3.8052(13)	63.80(6)	2.3708(10)	3.796(3)	9.239(10)
3.8027(13)	64.79(6)	2.3687(9)	3.794(3)	9.217(10)

3.7990(13)	66.22(5)	2.3697(9)	3.781(3)	9.195(10)

Supplementary Table 5. Experimental pressure conditions (P), unit cell parameters and volumes per formula unit for the Au pressure standard and the (Fe-1.9Si)$C_{0.09}H_{0.9}$ sample. The numbers between parentheses represent the error bar.

a, Å (Au)	P, GPa	a, Å ((Fe-1.9Si)$C_{0.09}H_{0.9}$)	b, Å ((Fe-1.9Si)$C_{0.09}H_{0.9}$)	c, Å ((Fe-1.9Si)$C_{0.09}H_{0.9}$)	β, ° ((Fe-1.9Si)$C_{0.09}H_{0.9}$)	V, Å^3
4.0278(13)	7.031(12)	4.560(14)	2.666(2)	4.267(12)	95.80(13)	12.90(6)
4.0208(13)	8.138(14)	4.550(4)	2.6595(7)	4.260(3)	95.93(4)	12.816(15)
4.0150(13)	9.074(11)	4.543(5)	2.6551(10)	4.253(4)	95.96(4)	12.754(21)
4.0064(13)	10.507(13)	4.528(3)	2.6465(8)	4.242(3)	96.04(3)	12.638(13)
3.9965(13)	12.232(14)	4.512(4)	2.6365(8)	4.228(3)	95.64(2)	12.511(15)
3.9873(13)	13.889(18)	4.501(3)	2.6293(7)	4.215(3)	96.05(2)	12.402(12)
3.9809(13)	15.088(18)	4.493(3)	2.6205(9)	4.210(3)	95.98(2)	12.325(13)
3.9653(13)	18.15(3)	4.472(3)	2.6115(9)	4.187(3)	96.02(3)	12.156(13)
3.9508(13)	21.16(3)	4.450(3)	2.5977(11)	4.170(4)	95.99(4)	11.986(16)
3.9453(13)	22.37(3)	4.449(3)	2.5914(13)	4.161(4)	95.97(3)	11.928(16)
3.9427(13)	22.95(3)	4.450(3)	2.5911(15)	4.150(4)	96.15(3)	11.894(14)

Supplementary Table 6. Experimental pressure conditions (P), unit cell parameters and volumes per formula unit for the Au pressure standard and the (Fe-1.9Si)$C_{0.09}H_{1.1}$ samples. The numbers between parentheses represent the error bar.

a, Å (Au)	P, GPa	a, Å ((Fe-1.9Si)$C_{0.09}H_{1.1}$)	b, Å ((Fe-1.9Si)$C_{0.09}H_{1.1}$)	c, Å ((Fe-1.9Si)$C_{0.09}H_{1.1}$)	β, ° ((Fe-1.9Si)$C_{0.09}H_{1.1}$)	V, Å^3
3.9224(13)	27.65(3)	4.452(4)	2.5915(7)	4.173(4)	96.18(4)	11.967(16)
3.9153(13)	29.41(4)	4.440(4)	2.5857(9)	4.166(3)	96.23(3)	11.888(14)
3.9076(13)	31.36(4)	4.428(3)	2.5796(9)	4.156(3)	96.32(3)	11.796(14)
3.8986(13)	33.72(5)	4.417(4)	2.5734(9)	4.145(3)	96.49(3)	11.702(14)
3.8867(13)	36.96(4)	4.402(4)	2.5657(9)	4.131(3)	96.53(3)	11.588(14)
3.8806(13)	38.67(5)	4.394(4)	2.5630(10)	4.125(4)	96.54(3)	11.540(14)
3.8744(13)	40.48(5)	4.385(3)	2.5554(7)	4.118(3)	96.54(2)	11.460(10)
3.8598(13)	44.89(6)	4.365(3)	2.5431(7)	4.103(3)	96.52(2)	11.314(10)
3.8564(13)	45.94(6)	4.360(3)	2.5405(5)	4.102(2)	96.48(2)	11.287(10)
3.8487(13)	48.42(5)	4.346(3)	2.5363(7)	4.094(3)	96.40(2)	11.211(11)
3.8433(13)	50.18(5)	4.336(3)	2.5306(7)	4.090(3)	96.46(2)	11.149(10)
3.8390(13)	51.63(6)	4.328(3)	2.5271(8)	4.086(3)	96.48(2)	11.101(12)
3.8360(13)	52.65(6)	4.325(3)	2.5253(7)	4.086(3)	96.37(2)	11.088(11)
3.8317(13)	54.11(4)	4.312(3)	2.5201(7)	4.082(2)	96.29(2)	11.023(10)
3.8286(13)	55.20(4)	4.308(3)	2.5191(8)	4.081(3)	96.30(2)	11.003(10)
3.8249(13)	56.51(5)	4.303(2)	2.5152(8)	4.076(2)	96.27(2)	10.964(10)
3.8191(13)	58.59(5)	4.293(3)	2.5123(9)	4.071(3)	96.27(2)	10.912(11)
3.8170(13)	59.39(5)	4.287(3)	2.5090(9)	4.072(3)	96.33(2)	10.884(11)
3.8130(13)	60.85(5)	4.284(3)	2.5054(9)	4.066(3)	96.22(2)	10.845(11)
3.8091(13)	62.31(5)	4.278(3)	2.5049(9)	4.061(3)	96.31(2)	10.814(11)
3.8052(13)	63.80(6)	4.275(3)	2.4999(9)	4.060(3)	96.40(2)	10.779(11)
3.8027(13)	64.79(6)	4.271(4)	2.4942(11)	4.061(3)	96.46(3)	10.748(14)

3.7990(13)	66.22(5)	4.270(3)	2.4910(9)	4.059(3)	96.41(2)	10.726(11)

Supplementary Table 7. Parameters for the Mie-Grüneisen-Debye model.

Parameter	γ_0	q	θ_0, K	m	a_0, K^{-1}	e_0, K^{-1}	g
Value	2±0.1	1±0.2	417	1.87	$3.7\cdot10^{-5}$	$1.95\cdot10^{-4}$	1.339
Ref.	[1]	[1]	[2]	[2]	[2]	[2]	[2]

Supplementary Table 8. density (σ_{Si}, σ_C, σ_H) and bulk sound velocity (β_{Si}, β_C, β_H) dependence coefficients for Si, C and H in Eq. (3)–(4) for the calculation of the density and the bulk sound velocity at 5500 K in the inner core. Note that individual errors presented in the table do not include covariances of parameters. As it is often the case for linear fits, the normalized covariance matrix of the fit parameters tends to be highly correlated. Thus, the uncertainties in Fig. 8 were calculated using the error propagation with the full covariance matrix of the fit parameters.

Parameter	Value
σ_{Si} (g/cm^3)	-19±4
σ_C (g/cm^3)	-16±8
σ_H (g/cm^3)	-64±28
β_{Si} (km/s)	8±4
β_C (km/s)	14±11
β_H (km/s)	19±23

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